FINE DENIER SPUNBOND PROCESS AND PRODUCTS THEREOF

Cross-Reference To Related Application

This application claims the priority of Provisional Application Serial No. 60/238,497, which was filed on October 6, 2000, and the disclosure of which is herein incorporated by reference.

Technical Field

The present invention relates generally to a method of continuously extruding essentially endless, thermoplastic polymer, fine denier filaments, and products produced thereby. Nonwoven fabrics embodying the present invention exhibit unique performance attributes, particularly when used in multiple layers, which offer improved barrier characteristics. Incorporation of at least one conventional filament layer onto a fine denier filament layer has resulted in fabrics, which have exhibited enhanced barrier performance in comparison to conventional continuous filament/melt-blown barrier constructs.

Background Of The Invention

Nonwoven fabrics are used in a wide variety of applications where the engineered qualities of the fabrics can be advantageously employed. The use of selected thermoplastic polymers in the construction of the fibrous fabric component, selected treatment of the fibrous component (either while in fibrous form or in an integrated structure), and selected use of various mechanisms by which the fibrous component is integrated into a useful fabric, are typical variables by which to adjust and alter the performance of the resultant nonwoven fabric.

In and of themselves, continuous filament fabrics are relatively highly porous, and ordinarily require an additional component in order to achieve the required barrier performance. Typically, barrier performance has been enhanced by the use of a barrier melt-blown layer of very fine filaments, which are drawn and fragmented by a high velocity air stream, and deposited into a self-annealing mass. Typically, such a melt-blown layer exhibits very low porosity, enhancing

the barrier properties of composite fabrics formed with spunbond and melt-blown layers.

Conventional spunbond/melt-blown /spunbond (SMS)-type fabrics for protective apparel are manufactured in a basis weight range of 60-65 grams per square meter, typically relying upon a melt-blown layer of more than 10 grams per square meter, to provide the desired barrier function. Ordinarily, these types of fabrics have a hydrostatic head rating of greater than 45 centimeters, before the addition or topical treatment of the constructs with alcohol resistant and anti-static chemistries.

Further prior art improvements on the SMS construct have been made by incorporating multiple light-weight melt-blown barrier layers, i.e. SMMS fabrics, in lieu of single heavy-weight melt-blown layers. Fabrication in this manner has been found to reduce hydrostatic head failures, which can otherwise result due to defects that are common in melt-blown fabrics; the plural melt-blown layers compensate for defects, which may exist in any one layer. While multiple melt-blown layers act to facilitate manufacturing efficiency, the complexity of such a process requires additional equipment for each subsequent layer.

U.S. Patent No. 5,464,688 teaches the use of modified polypropylene resin with a higher melt flow rate to produce a melt-blown web having average fiber diameters of from 1 to 3 microns and pore sizes distributed in the range from 7 to 12 microns compared to previously reported melt-blown webs, which have pore sizes distributed predominantly in the range from 10 to 15 microns.

U.S. Patent No. 5,482,765 teaches the addition of fluorocarbons to either the melt-blown or spunbond layer and a melt-blown layer with between 5 and 20% polybutylene. Such modifications provide a laminate having improved barrier and strength to weight ratios. The enhancement is measured by the ratio of hydrostatic head to melt-blown layer basis weight of greater than 115 cm/osy (3.38 cm/gsm).

The present invention contemplates that the provision of one or more fine denier spunbond layers significantly improves the overall barrier performance of

the composite fabric. The fine denier spunbond layer provides a more uniform interface between the spunbond layer and a subsequent barrier layer applied during the manufacture of the nonwoven fabric, resulting in improved barrier performance in the fabricated article.

Summary Of The Invention

The present invention is directed to a nonwoven composite fabric comprising one or more layers of fine denier spunbond filaments and at least one layer of barrier material, wherein said nonwoven composite fabric has a significantly improved barrier performance as measured by the hydrostatic head to barrier layer basis weight ratio being of about at least 4.9 cm/gsm. In a preferred embodiment of the present invention, first and second outer fabric layers are formed, each comprising continuous filament spunbond layers of thermoplastic fibers, with the size of the continuous filaments between about 0.7 and 1.2 denier, preferably less than or equal to 1 denier. The barrier layer preferentially comprises microfibers of finite length, wherein the average fiber diameter is in the range of about 1 micron to about 10 microns, and preferably between about 1 micron and 5 microns, said layers being consolidated into a composite fabric.

The thermoplastic polymers of the continuous filament spunbond layer or layers are chosen from the group consisting of polyolefins and polyesters, wherein the polyolefins are chosen from the group consisting of polypropylene, polyethylene, and combinations thereof. It is within the purview of the present invention that the continuous filament spunbond layer or layers may comprise either the same or different thermoplastic polymers. Further, the continuous filaments of the spunbond layer or layers may comprise homogeneous, bicomponent, and/or multi-component profiles and the blends thereof.

The barrier layer comprises a material selected from suitable media, such media include: melt-blown, cellulosic pulp, microporous film or monolithic film, with a microfiber media such as melt-blown being preferred. The thermoplastic polymers of the melt-blown microfibers are chosen from the group consisting of polyolefins and polyesters, wherein the polyolefins are

chosen from the group consisting of polypropylene, polyethylene, and combinations thereof. It is within the purview of the present invention that the microfibers may comprise either the same or different thermoplastic polymers. Further, the microfibers may comprise homogeneous, bicomponent, and/or multi-component profiles and the blends thereof. The melt-blown layer is in the basis weight range of less than or equal to about 10 grams per square meter, the basis weight of between 1 and 8 grams per square meter being most preferred.

In a further aspect of the method of producing a nonwoven fabric in accordance with the present invention, formation of a composite fabric structure entails the formation of first and second outer, spunbond web layers, and plural barrier melt-blown layers, for example, two, melt-blown barrier layers. Preferably, each of the outer, spunbond web layers are formed from a plurality of endless filaments having a denier of between 0.7 and 1.2 denier, with each outer layer preferably formed with the same basis weight, and from the same denier filaments. Formation of plural barrier melt-blown layers can be effected such that each of the melt-blown layers is formed to have the same basis weight.

In a fabric formed in accordance with the present invention, the incorporation of fine denier spunbond layers provide substantial improvement in barrier function, allowing for reduction in the amount of the spunbond and /or barrier layer required to meet performance criteria. The fine denier spunbond layer provides a more uniform support layer for the barrier layer during the manufacturing process providing substantial improvement in barrier function in the resulting end-use articles.

Formation of fabrics from fine denier spunbond materials, particularly when combined with one or more barrier melt-blown layers, has been found to provide enhanced barrier properties. The present invention allows the production of a same weight fabric with improved barrier properties or a lighter weight fabric that is suitable for use as a barrier fabric, particularly for medical gowns and industrial protective apparel. Use of the present fabric as a battery separator component is also contemplated.

Other features and advantages of the present invention will become readily apparent from the following detailed description, the accompanying drawings, and the appended claims.

Brief Description Of The Drawings

FIGURE 1 is a plan view of a diaper embodying this invention, the diaper being shown in an uncontracted state.

FIGURE 2 is an elevation of a surgical gown embodying this invention.

Detailed Description

While the present invention is susceptible of embodiment in various forms, there will hereinafter be described, presently preferred embodiments, with the understanding that the present disclosure is to be considered as an exemplification of the invention, and is not intended to limit the invention to the specific embodiments disclosed herein.

The present invention is directed to a nonwoven composite fabric, which entails formation of a layer of fine denier spunbond filaments and at least one layer of barrier material. In order to achieve desired barrier properties to weight ratios for the fabric structure, the spunbond filaments preferably have a denier in the range of about 0.7 to 1.2, and preferably have a denier less than or equal to about 1.

A spunbond process involves supplying a molten polymer, which is then extruded under pressure through a large number of orifices in a plate known as a spinneret or die. The resulting continuous filaments are quenched and drawn by any of a number of methods, such as slot draw systems, attenuator guns, or Godet rolls. The continuous filaments are collected as a loose web upon a moving foraminous surface, such as a wire mesh conveyor belt. When more than one spinneret is used in line for the purpose of forming a multi-layered fabric, the subsequent webs is collected upon the uppermost surface of the previously formed web. The web is then at least temporarily consolidated, usually by means involving heat and pressure, such as by thermal point bonding. Using this bonding means, the web or layers of webs are passed between two hot metal rolls, one of which has an embossed pattern to impart and achieve the

desired degree of point bonding, usually on the order of 10 to 40 percent of the overall surface area being so bonded.

The thermoplastic polymers of the continuous filament spunbond layer or layers are chosen from the group consisting of polyolefins and polyesters, wherein the polyolefins are chosen from the group consisting of polypropylene, polyethylene, and combinations thereof. It is within the purview of the present invention that the continuous filament spunbond layer or layers may comprise either the same or different thermoplastic polymers. Further, the continuous filaments of the spunbond layer or layers may comprise homogeneous, bicomponent, and/or multi-component profiles and the blends thereof.

The barrier layer comprises a material selected from suitable media, such media include: melt-blown, cellulosic pulp, microporous film or monolithic film, with microfiber media such as melt-blown being preferred. Cellulosic pulp barrier layers are well-known for providing a useful barrier performance in medical applications and include such materials as wood pulp, in either a wetlaid tissue form or as an airlaid fibrous layer. Suitable microporous film barrier layer can include materials such as those reported in U.S. Patent No. 5,910,225, the disclosure of which is herein incorporated by reference, in which pore-nucleating agents are used to form the micropores. Monolithic films as reported in U.S. Patent No. 6,191,221, the disclosure of which is herein incorporated by reference, can also be utilized as a suitable barrier means.

A preferred mechanism for forming a barrier layer is through application of the melt-blown process. The melt-blown process is a related means to the spunbond process for forming a layer of a nonwoven fabric, wherein, a molten polymer is extruded under pressure through orifices in a spinneret or die. High velocity air impinges upon and entrains the filaments as they exit the die. The energy of this step is such that the formed filaments are greatly reduced in diameter and are fractured so that microfibers of finite length are produced. This differs from the spunbond process whereby the continuity of the filaments is preserved. The process to form either a single layer or a multiple-layer fabric is continuous, that is, the process steps are uninterrupted from extrusion of the

filaments to form the first and subsequent layers through consolidation of the layers to form a composite fabric.

To form fine denier spunbond layers from conventional spunbond equipment, several process parameters are modified. The fine-fiber spunbond material is made by decreasing the extrusion rate, while increasing the rate of the filaments. A thermoplastic polymer can be selected to provide adequate melt strength so as to minimize fiber breaks during the fiber draw-down process. The actual extrusion and quench temperatures utilized and the other specific changes to the process will depend upon the polymer resin and the specific spunbond equipment. Specialized, performance-enhanced spunbond layers such as those high-speed spinning processes taught in U.S. Patent No. 5,885,909, the disclosure of which is herein incorporated by reference, can also be practiced.

The melt-blown process, as well as the cross-sectional profile of the spunbond filament or melt-blown microfiber are not a critical limitation to the practice of the present invention.

By providing a fine denier spunbond layer upon which the melt-blown layer is deposited, several enhancements of the fabric are realized. For a given basis weight of the spunbond layer, a finer denier fabric will give a greater number of filaments and a smaller average pore size. The smaller average pore size will result in a more uniform deposition of the melt-blown microfibers onto the spunbond layer. A more uniform melt-blown layer will have fewer weak points in the web at which a failure in barrier performance can occur. The spunbond layer also serves to support the melt-blown layer structurally in the composite material. A finer denier spunbond layer provides a smaller average pore size and a larger number of support points for the barrier layer; this results in shorter spans of unsupported melt-blown microfibers. This mechanism embodies the well-known concept that reduction in the average span length results in enhanced structural integrity.

Examples

Example 1 is a conventional SMS fabric comprising a spunbond layer basis weight being 17 gsm and a melt-blown basis weight being 10 gsm. This

construct was made in accordance with standard practices as applied to equipment supplied by Reifenhauser GmbH for the formation of fabric by thermal point bonding in a diamond pattern at a coverage area of 17%. A thermoplastic resin was provided in the form of polypropylene 3155 available from Exxon Corporation.

Example 2 is a conventional SMMS fabric comprising a spunbond layer basis weight being 15 gsm and a melt-blown basis weight being 7.5 gsm. This construct was made in accordance with standard practices as applied to equipment supplied by Reifenhauser GmbH for the formation of fabric by thermal point bonding in a diamond pattern at a coverage area of 17%. A thermoplastic resin was provided in the form of polypropylene 3155 available from Exxon Corporation.

Example 3 is an SMS fabric made in accordance with the present invention, comprising a spunbond layer basis weight being 17 gsm and a melt-blown basis weight being 8 gsm. The polypropylene resin used to form the spunbond layer was Achieve® 3854 available from Exxon Corporation. This construct was made in accordance with standard practices as applied to equipment supplied by Reifenhauser GmbH for the formation of fabric by thermal point bonding in an oval pattern at a coverage area of 18%.

Example 4 is an SMMS fabric made in accordance with the present invention, comprising a spunbond layer basis weight being 10 gsm and amelt-blown basis weight being 5 gsm. The polypropylene resin used to form the spunbond layer was Achieve® 3854 available from Exxon Corporation. This construct was made in accordance with standard practices as applied to equipment supplied by Reifenhauser GmbH for the formation of fabric by thermal point bonding in an oval pattern at a coverage area of 18%.

Example 5 is an SMMS fabric made in accordance with the present invention, comprising a spunbond layer basis weight being 17 gsm and a melt-blown basis weight being 8 gsm. The polypropylene resin used to form the spunbond layer was Achieve® 3854 available from Exxon Corporation. This construct was made in accordance with standard practices as applied to

equipment supplied by Reifenhauser GmbH for the formation of fabric by thermal point bonding in an oval pattern at a coverage area of 18%.

Example 6 is an SMMS fabric made in accordance with the present invention, comprising a spunbond layer basis weight being 6 gsm and a melt-blown basis weight being 2.5 gsm. The polypropylene resin used to form the spunbond layer was Achieve® 3854 available from Exxon Corporation. This construct was made in accordance with standard practices as applied to equipment supplied by Reifenhauser GmbH for the formation of fabric by thermal point bonding in an oval pattern at a coverage area of 18%.

Example 7 is an SMS fabric made in accordance with the present invention, comprising a spunbond layer basis weight being 7 gsm and a melt-blown basis weight being 3 gsm. The polypropylene resin used to form the spunbond layer was Achieve® 3854 available from Exxon Corporation. This construct was made in accordance with standard practices as applied to equipment supplied by Reifenhauser GmbH for the formation of fabric by thermal point bonding in an oval pattern at a coverage area of 18%.

For comparison purposes, examples of SMS fabrics from the U.S. patent literature are also included in Table 1. Comparative sample A is a polypropylene SMS fabric described in U.S. Patent No. 5,464,688. Comparative sample B is a polypropylene SMS fabric described in U.S. Patent No. 5,482,765.

Table 1 sets forth composite fabrics formed in accordance with the present invention compared to conventional SMS and SMMS fabrics. Testing was done in accordance with the following standard test methods.

Test	Method
Basis weight (grams/meter^2)	ASTM D3776
Tensiles MD and CD Grab (g/cm)	ASTM D5034
Tensiles MD and CD Elongation (%)	ASTM D5034
Tensiles MD and CD Strips	ASTM D5035
Tensiles MD and CD Elongation Strips	ASTM D5035
Hydrostatic head (cm)	INDA 80.4

In Table 1, the regular denier SMS material (Example 1) is shown as having layers formed with various individual basis weights of 17 gsm/10 gsm/17 gsm. The denier of the spunbond layer was measured by common technique and was found to be 1.7 denier. The melt-blown fiber diameters were measured to give an average of 2.0 microns. An SMMS material (Example 2) is also shown in Table 1, as having layers formed with various individual basis weights of 15 gsm/7.5gsm/7.5 gsm/15 gsm. The spunbond layers have filaments of 2.3 denier and the average melt-blown diameter is 2.8 microns. The conventional SMS and SMMS fabrics exhibit hydrostatic head values of 36.8 and 53 cm respectively. Normalization of the hydrostatic head values for the two constructions to the melt-blown basis weight gives values of 3.7 and 3.5 cm/gsm, respectively.

Example 3 represents a polypropylene SMS fabric made in accordance with the invention, with individual layers of the following basis weights, 17 gsm/8 gsm/17 gsm. The denier of the spunbond layer was measured by common technique and was found to be 1.0 denier. The melt-blown fiber diameters were measured to give an average of 2.1 microns. The hydrostatic head to basis weight ratio for the fabric of Example 3 is 6.1. The improvement of barrier property in the material made in accordance with this invention as measured by hydrostatic head represents a 65% increase per gram per square meter of the melt-blown barrier layer.

Comparative sample of SMS barrier fabrics reported in the U.S. Patent literature are listed in Table 1. The total basis weight for these two fabrics is 47 and 54 gsm respectively, with each fabric having a melt-blown basis weight of 17 gsm. The hydrostatic head to basis weight ratio for these products are 1.8 and 3.1 cm/gsm respectively. These values are significantly lower than the values found for Example 3.

Example 4 represents a polypropylene SMMS fabric made in accordance with the invention, with individual layers of the following basis weights, 10 gsm/5 gsm/5 gsm/10 gsm. The denier of the spunbond layer was measured by common technique and was found to be 1.1 denier. The melt-blown fiber

diameters were measured to give an average value of 1.9 microns. The hydrostatic head to basis weight ratio for the fabric of Example 4 is 4.9 cm/gsm. The improvement of barrier property in the material made in accordance with this invention as measured by hydrostatic head represents a 40% increase per gram per square meter of the melt-blown barrier layer.

Example 5 represents a polypropylene SMMS fabric made in accordance with the invention, with individual layers of the following basis weights, 17 gsm/8 gsm/8 gsm/17 gsm. The hydrostatic head value for this fabric is 90 cm, making this material suitable for use in medical applications such as medical gowns.

Other representative fabrics are presented in Table 2. Examples 6-7 demonstrate the high ratio of hydrostatic head to melt-blown basis weight, 7.4 and 7.8 cm/gsm respectively, in lightweight constructs as embodied in the present invention. Such lightweight constructs are particularly advantageous when used in the fabrication of end-use articles requiring significant barrier performance.

Disposable waste-containment garments are generally described in U.S. Patents No. 4,573,986, No. 5,843,056, and No. 6,198,018, the disclosures of which are incorporated herein by reference.

An absorbent article incorporating an improved barrier fabric of the present invention is represented by the unitary disposable absorbent article, diaper 20, shown in FIG. 1. As used herein, the term "diaper" refers to an absorbent article generally worn by infants and incontinent persons that is worn about the lower torso of the wearer. It should be understood, however, that the present invention is also applicable to other absorbent articles such as incontinence briefs, incontinence undergarments, diaper holders and liners, feminine hygiene garments, training pants, pull-on garments, and the like.

FIG. 1 is a plan view of a diaper 20 in an uncontracted state (i.e., with elastic induced contraction pulled out) with portions of the structure being cut-away to more clearly show the construction of the diaper 20. As shown in FIG. 1, the diaper 20 preferably comprises a containment assembly 22 comprising a

liquid pervious topsheet 24; a liquid impervious backsheet 26 joined to the topsheet; and an absorbent core 28 positioned between the topsheet 24 and the backsheet 26. The absorbent core 28 has a pair of opposing longitudinal edges, an inner surface and an outer surface. The diaper can further comprise elastic leg features 32; elastic waist features 34; and a fastening system 36, which preferably comprises a pair of securement members 37 and a landing member 38.

Practical application of an improved barrier fabric as described in this invention for backsheet 26 results in a diaper that is lighter in weight while maintaining performance. A lighter weight backsheet material is expected to be more flexible and therefore more conforming to deformation of the overall structure as the diaper is worn.

Catamenial products, such as feminine hygiene pads, are of the same general construction as the aforementioned diaper structure. Again, a topsheet and a backsheet are affixed about a central absorbent core. The overall design of the catamenial product is altered to best conform to the human shape and for absorbing human exudates. Representative prior art to such article fabrication include U.S. Patents No. 4,029,101, No. 4,184,498, No. 4,195,634, No. 4,408,357 and No. 4,886,513, the disclosures of which are incorporated herein by reference.

Medical and industrial protective products, such as CSR, medical gown, surgical drape and oversuits can benefit significantly from the inclusion of an improved barrier fabric as described in the present invention. Of particular utility in the fabrication of such protective products is the use of lighter weight fabrics with improved barrier to weight ratios, as it is important for the finished product to be as lightweight as possible yet still perform its desired function. Patents generally describing such protective products include U.S. Patents No. 4,845,779, No. 4,876,746, No. 5,655,374, No. 6,029,274, and No. 6,103,647, the disclosures of which are incorporated herein by reference.

Referring now to FIG. 2, there is shown a disposable garment generally designated 110 comprising a surgical gown 112. The gown 112 comprises a

body portion 114, which may be one-piece, having a front panel 116 for covering the front of the wearer, and a pair of back panels 118 and 120 extending from opposed sides of the front panel 116 for covering the back of the wearer. The back panels 118 and 120 have a pair of side edges 122 and 124, respectively, which define an opening on the back of the gown. The gown 112 has a pair of sleeves 126 and 128 secured to the body portion 114 of the gown for the arms of the wearer. In use, the back panels 118 and 120 overlap on the back of the wearer in order to close the back opening of the gown, and suitable belt means (not shown) is utilized to secure the back panels 118 and 120 in the overlapping relationship.

SMS composite fabric is routinely used as a battery separator between the positive and negative plates of a battery cell in order to inhibit physical contact between the two opposing plates. The battery separator must allow for the free flow of electrons that are produced due to the chemical activity within the cell, but must also provide a barrier such that any active paste-like substances are prevented from penetrating the separator material. With the highly improved barrier properties of the nonwoven composite fabrics of the present invention, lighter weight and less bulky fabrics may be employed, for example, as battery separators. Less bulky fabrics allow for closer spacing of the anode and cathode and an increase in the active material in the battery for a given volume.

From the foregoing, numerous modifications and variations can be effected without departing from the true spirit and scope of the novel concept of the present invention. It is to be understood that no limitation with respect to the specific embodiments disclosed herein is intended or should be inferred. The disclosure is intended to cover, by the appended claims, all such modifications as fall within the scope of the claims.

Table 1

		Examples					Comparative Examples	
PROPERTY	UNIT	1	2	3	4	5	A	B
Layer basis weight	gsm	17/10/17	15/7.5/7.5/15	17/8/17	10/5/5/10	17/8/8/17	15/17/15	18.7/17/18.7
Fabric basis weight	gsm	44	45	42	30	50	47	54
Melt blown basis weight	gsm	10	15	8	10	16	17	17
MD Grabs	g/cm	5960	4590	8102	4890	3776	-	-
CD Grabs	g/cm	4120	3253	6472	3473	2631	-	-
MD Elongation	%	62	55.5	50	50	39	-	-
CD Elongation	%	80	65.5	72	64	57	-	-
Hydrostatic head (HSH)	cm	36.8	53	49	49	90	29.9	53
HSH/Melt-blown Basis Weight	cm/gsm	3.7	3.5	6.1	4.9	5.6	1.8	3.1

Table 2

		Examples	
PROPERTY	UNIT	6	7
Layer basis weight	gsm	6/2.5/2.5/6	7/2/2/7
Fabric basis weight	gsm	17	18
Melt-blown basis weight	gsm	5	4
MD Strips	g/cm	448	324
CD Strips	g/cm	121	61
MD Elongation	%	19	20
CD Elongation	%	121	30
Hydrostatic head (HSH)	cm	37	31
HSH/Melt-blown basis weight	cm/gsm	7.4	7.8